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Using a Spatial Growth Model to Provide Evidence of Agricultural Spillovers between Countries in the NEPAD CAADP Framework

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ABSTRACT

The NEPAD Comprehensive Africa Agriculture Development Programme (CAADP) has been endorsed by African Heads of State and Governments as a vision for the restoration of agricultural growth, food security, and rural development in Africa. The program aims at stimulating agriculture-led development to alleviate poverty and hunger, and achieve sustainable food security. The creation of a union is often rationalized on grounds of moving the equilibrium toward the first best solution whenever independent policies generate spillovers. This arises as a common agenda can significantly reduce the scope of free-riding behavior among member countries. In addition, cross-border externalities arising out of higher levels of market integration entails countries to agree on policy coordination. Using a Spatial Durbin Model for panel data, the present study explores the extent and magnitude of agricultural production spillover that might validate the adoption of CAADP agenda among African countries, especially among Sub-Saharan African countries. Overall, our results suggest the presence of positive and significant agricultural production spillover. No evidence of beggar-thy-neighbor or negative spillover policies was found; on average, each country received 2.5 percent growth as a result of spillover. Finally, our results suggest that convergence dynamics is much stronger when spillover is accounted for which provides a rationale for a common agenda such as CAADP.

Keywords: CAADP, spillover, agriculture, production, spatial model, growth, convergence

1. INTRODUCTION

The majority of poor people in Africa live in rural areas and depend directly or indirectly on agriculture for their livelihoods. Sustainable poverty alleviation strategies should thus focus on improving agricultural productivity. As pointed out by Pratt and Yu (2008), policy reforms undertaken by many African countries between the mid-1980s and the second half of the 1990s have played an important role in improving agriculture's performance. The trend of total factor productivity (TFP) suggests a remarkable recovery in the performance of Sub-Saharan Africa's agriculture during the years from 1984 to 2003 after a long period of poor performance and stagnation in output.

However, to sustain high productivity growth in agriculture in the future, African countries in general and Sub-Saharan countries in particular will need well-designed and better-coordinated policies to improve the productivity of smallholder farmers, who constitute the backbone of the agricultural sector in Africa. Such a common policy agenda should cover market and trade opportunities at domestic, regional, and international levels by providing appropriate incentives, including infrastructure for improved market access. Infrastructure remains poor in most Sub-Saharan African countries with the consequence that markets in many countries are often poorly integrated and characterized by a low level of competition.

The lack of market integration implies that production shortfalls cannot easily be reversed via intraregional, interregional, or international trade, which may explain why the incidence of food emergencies remains high in many countries of the region. As a result, even while food production increases in some areas, food emergencies might not be averted in nearby zones due to the deficiencies in the structure and distribution of local markets and their lack of coordination with national and international distribution systems (Stringer and Pingali 2004; NEPAD Secretariat 2005). Therefore, there is a need for organizations such as the New Partnership for Africa's Development (NEPAD) and regional economic communities (RECs) to initiate coordinated actions to improve access to public services and markets, hold governments accountable, make markets work for both public and private sectors, and address collective issues facing smallholder farmers. The main question then becomes how to design and implement a collective agricultural agenda aimed at lifting people out of poverty and hunger through improved agricultural productivity.

In order to address the above question, it is important to note that there are two broad strands of thought on the potential role of agriculture for Sub-Saharan African countries. The first view emphasizes the role of agricultural development within a market-based economic framework (Binswanger 2001; Stringer and Pingali 2004; DFID 2003). In contrast, the second school of thought highlights the potential of growth and poverty reduction through the rural off-farm sector or manufacturing exports (Ellis 2003; Fafchamps, Teal, and Toye 2001). Regardless of how agriculture is viewed, agricultural development and poverty reduction goals cannot be achieved simultaneously unless more attention is given to the agricultural sector in terms of both policy and investments. For many African countries, agricultural growth will remain the platform for initiating both forward and backward linkages to the rest of the economy in the coming decades and thus will have strong spillover effects in raising agricultural productivity and incomes (Reardon, Bergegué, and Escobar 2001). As a result, strategies and policies that aim at reducing food insecurity and poverty in the medium to long term should focus on addressing these issues not only within the agricultural sector alone but also through its interactions with the rest of the economy.

Adoption of common agricultural policies has the potential to exploit the continent's abundant natural resources and achieve significant economies of scale, thereby making the sector globally competitive. In addition, by addressing access to interregional and intraregional trade for smallholder farmers, improvement of technology through sustainable natural resource management practices, and the fragility of different ecosystems in the region, common agricultural policies can strengthen the role of farmers' organizations and improve the productivity and incomes of smallholder farmers. However, there are also significant costs associated with common agricultural policies because member countries lose part of their sovereignty through engaging in a common process of setting up policies and strategies. In

addition, overlaps in memberships, mandates, objectives, and protocols are also likely to generate "unhealthy multiplication and duplication of efforts" that lead to implementation challenges when two or more programs try to address the same set of issues (United Nations Economic Commission for Africa 2006, 4). Moreover, regional integration through RECs remains inefficient and to a large extent resource-constrained owing to "the substantial gaps between what is written in treaties and what happens on the ground" (Wambo 2006, 7).

In theory, adoption of a common agenda should improve the efficiency of policy outcome whenever independent policies generate spillovers (Etro 2001). This arises because a common agenda can significantly reduce the scope of free-riding behavior among member countries. The present study seeks to determine whether there is evidence of spillovers that might justify the adoption of the Comprehensive Africa Agriculture Development Programme (CAADP) agenda among Sub-Saharan African countries. We also explore the possible impact of agricultural production spillover on the spatiotemporal dynamics of agricultural production among Sub-Saharan African countries.

This paper is organized as follows: In the next section, we discuss the current trends and challenges facing agricultural development in Africa while highlighting a few areas where cross-country externalities can arise. Section 3 discusses the conceptual framework of the role of spatial externalities and the priority areas of cooperation for regional, international, and national bodies. Section 4 formulates the spatial econometric model used in the study. The next two sections provide the main results of the study and a discussion based on the results of the rationale of a common agricultural policy. The final section provides some concluding thoughts on how best to rationalize a common agricultural strategy for Africa that can ensure the unification of programs, activities, and functions of regional and national agencies.

2. ISSUES FACING AGRICULTURAL DEVELOPMENT IN SUB-SAHARAN AFRICA AND POLICY RESPONSES

In Asia, the considerable homogeneity of production conditions over extensive areas of irrigated land with similar agroecological conditions, the presence of inputs and product markets, and a supportive institutional environment has fostered rapid adoption of new technologies and created large productivity gains in what has been called the "green revolution" (de Janvry and Sadoulet 2008). In contrast, the situation in Africa is different owing to the complexity of the constraints specific to the region, such as small and fragmented markets, heterogeneous agroclimatic zones, lower accessibility of services (including agricultural extension and advice, credit, storage infrastructures, and so on), and unsustainable natural resource management practices (Dorward et al. 2004). In addition, there are extensive market and government failures in African agriculture. While market failures prevent the private sector from actively engaging in market activities, government failures, in contrast, prevent the private sector from undertaking any investment projects that yield higher returns in the future.

Agricultural development in Sub-Saharan Africa remains a complicated policy arena with multiple and diverse actors, ranging from subsistence farmers to multinational firms and parastatal corporations, with these actors having multiple development goals. These goals include productivity growth, livelihood and food security, and environmental sustainability. Since institutional capacities, resources, and results-based monitoring and evaluation are still inadequate and are not well coordinated, it will be important to strengthen statistical data collection, monitoring, and evaluation capabilities that track changes in key variables over time. This will help in guiding strategies and investments for achieving goals such as improved livelihoods, food security, and sustainable natural resource management practices.

As rightly pointed out by de Janvry and Sadoulet, the conditions to use agriculture for development must encompass those "under which agriculture now operates: globalization, economies of scale in integrated supply chains, technological revolutions in biology and information systems, new financial services, redefined roles for the state and producer organizations, and, overwhelmingly, climate change and the associated uncertainties" (2008, 16). Thus, it is still a matter of debate whether uniform indicators such as allocating 10 percent of the budget for agriculture and targeting 6 percent agricultural growth are enough to move the CAADP forward.

The agricultural sector in Sub-Saharan Africa relies heavily on small-scale farming. The general consensus is that smallholder farmers and other small and medium enterprises in the rural nonfarm economy cannot compete alone in global markets. They need to cooperate with other large agrobusiness enterprises so as to achieve competitiveness through cluster development (Berdegué 2001). Linkages through contract farming can produce positive spillovers through higher supply, better planning cycles, and limited exposure to fluctuations in international markets (Felgenhauer and Labella 2008).

Following the Berg report (World Bank 1981) in the early 1980s, it was recognized that improving agricultural policies was critical for achieving higher agricultural growth. Suggested key areas of reform included the following:

- Reforming incentive structures to ensure better prices for smallholder farmers
- Opening up agricultural marketing systems to allow for competition
- Rehabilitating marketing infrastructure, rural roads, and irrigation equipment
- Making improvements in crop and livestock research and pest control

The above areas of structural adjustment programs (SAPs) were less focused on an agricultural strategy and more centered on short-term macroeconomic stabilization (Kherallah et al. 2002). However, the second phase of SAPs (1985–1998) was more proactive, with increasing attention given to agricultural market reforms. These reforms included the following:

- Liberalization of agricultural input and output prices by reducing or removing subsidies on inputs such as fertilizers
- Doing away with pan-seasonal and pan-territorial prices
- Reducing overvalued exchange rates
- Removing government regulatory controls in input and output markets
- Privatization by withdrawing marketing boards from pricing and marketing activities and restructuring public enterprises (Kherallah et al. 2002; Jayne et al. 2002)

Barrett and Carter succinctly summarize agricultural policy reforms as follows: "Once governments free marketing channels and prices (including exchange rates), private merchants bid up formerly depressed agricultural prices. By virtue of a positive price elasticity of supply, higher prices induce greater production and increased production stimulates demand for purchased inputs, including hired labor. Larger agricultural incomes have significant multiplier effects due to relatively poor farmers' high marginal propensity to consume. Thus a liberalized agricultural sector is expected to propagate prosperity across all sectors of the economy in a distributionally progressive manner" (1994, 288).

Based on the extent of implementation or nonimplementation, Jayne and colleagues (2002) categorized countries into three groups: (1) committed to reforms, such as Mozambique, Uganda, Mali, and Ghana, countries that adhered to fertilizer and maize market reforms; (2) resistant to reforms, such as Zimbabwe, which resisted maize market reforms prior to 1991 and reimposed controls after 1998; (3) practicing de jure reform and de facto state control, such as Zambia, which maintained state control of fertilizer marketing while implementing other reform elements.

The limitations of SAPs in terms of strategy formulation and implementation for the agricultural sector are as follows: (1) lack of emphasis on supporting market institutions and infrastructure; (2) lack of participation and ownership in the design and implementation of SAPs by governments and other stakeholders, such as civil society and farmers; (3) minimal private-sector response; (4) limitations with ex ante policy conditionality; (5) limited or no agricultural supply response; and (6) failure of SAPs (SAP1 and SAP2) to make a meaningful impact on growth and poverty reduction.

A decade into SAPs, Africa was still lagging behind; thus, poverty reduction strategy papers (PRSPs) were initiated to lay out macroeconomic and social programs and policies to be pursued by a country over a three- or five-year period in order to promote growth and reduce poverty. A review of several completed PRSPs suggests that while countries acknowledge the important role of agriculture in accelerating "pro-poor" growth, agricultural policies of the SAP era have largely been maintained (Diao et al. 2007). Despite the shortcomings of the SAP reforms, their second generation strongly emphasized the role of agriculture as an engine of growth for most African countries and brought to the attention of policymakers the factors that undermined agricultural productivity growth. The PRSP rhetoric on the importance of agriculture was, however, not matched by increased investments in the sector (by both governments and donors); agricultural research and development, extension services, and rural infrastructure development were widely neglected.

3. NEPAD'S VISION FOR AGRICULTURAL GROWTH IN AFRICA[1]

In adopting the Comprehensive Africa Agriculture Development Programme (CAADP), African governments set for their countries a collective goal of achieving a 6 percent agricultural growth rate as a key strategy toward achieving the Millennium Development Goal of halving the poverty rate by 2015 from its 1990 level. They also opted for a partnership framework to mobilize the required funding to achieve this growth rate, including national governments' allocating at least 10 percent of their budgets to the agricultural sector. Finally, CAADP also reflects an option for evidence- and outcome-based planning and implementation in support of an inclusive sectoral review and dialogue process, in line with the broader NEPAD peer review and accountability principle. Figure 1 presents an overview of CAADP functions and key players.

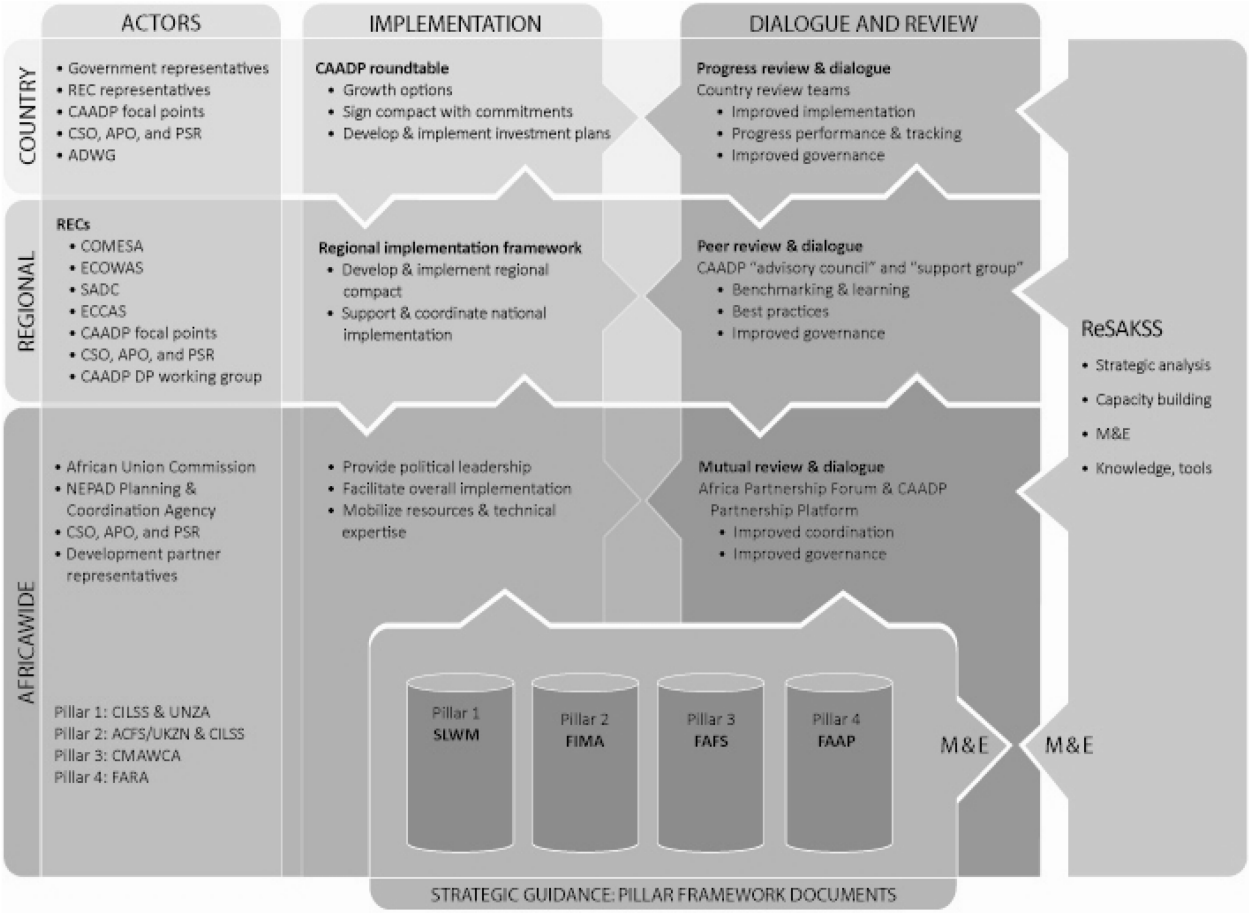
In promoting CAADP, the NEPAD framework has developed a vision of agriculture-led development in Africa that seeks to eliminate hunger and reduce food insecurity through an expansion of agriculture-led exports. As described below, the CAADP framework is built around four main technical pillars:

1. *Expanding the area under sustainable land management and reliable water control systems.* Pillar 1 objectives are as follows: (a) to reverse fertility loss and resource degradation, and ensure broad-based and rapid adoption of sustainable land and forestry management practices in the smallholder as well as commercial sectors; and (b) to improve management of water resources while expanding access to both small- and large-scale irrigation.
2. *Improving rural infrastructure and trade-related capacities for market access*. The objectives of pillar 2 are as follows: (a) to accelerate growth in the agricultural sector by raising the capacities of private entrepreneurs, including commercial and smallholder farmers, to meet the increasingly complex quality and logistical requirements of markets (domestic, regional, and international), focusing on selected agricultural commodities that offer the potential to raise rural (on- and off-farm) incomes; and (b) to establish a regulatory and policy framework that would expand regional trade and cross-border investments through the creation of regional economic actors.
3. *Increasing food supply and reducing hunger*. The objectives of pillar 3 are as follows: (a) to create well-managed and regionally coordinated food reserves and early warning systems at the national level that would allow African countries to respond in a timely and cost-effective manner to food crises; (b) to reduce malnutrition in schoolchildren through diet supplementation with a complete meal that is adequate in carbohydrates, fat, protein, vitamins, and minerals, and to expand local demand and stimulate production by smallholder farmers; and c) to develop an African nutrition initiative to meet countries' broader nutritional challenges in a way that takes account of the complex and multisectoral nature of the problem and possible solutions.
4. *Expanding agricultural research and the dissemination and adoption of technology*. The objectives of pillar 4 are as follows: (a) to achieve rapid flow of technologies suitable in the African context that are responsive to the constraints and opportunities facing farmers; (b) to mobilize the large potential of cassava that can contribute to food security and income generation among African countries; c) to contribute to food security and poverty reduction, and ensure sustainable resource management, in the rice sector of 10 eastern, central, and southern African countries through broad-based access to high-yielding New Rice for Africa (NERICA) rice lines, other improved varieties, and accompanying technologies; and d) to safeguard the future contribution of Africa's fish sector to poverty alleviation and regional economic development, in particular through improved management of natural fish stocks, development of aquaculture production, and expansion of fish marketing and trade.

[1] See Badiane (2009).

The CAADP framework also addresses three clusters of critical issues that cut across the four CAADP pillars: academic and professional training to upgrade skills in the agricultural sector; information and knowledge systems to support sector strategy and policy formulation and implementation; and alignment of country poverty reduction strategy papers (PRSPs) with CAADP priorities and objectives.

Figure 1. Overview of CAADP implementation functions and processes



Source: Badiane 2009.
Notes: ACFS/UKZN: African Center for Food Security at the University of KwaZulu Natal; CAADP: Comprehensive Africa Agriculture Development Programme; CILSS: Permanent Inter-state Committee for Drought Control in the Sahel; CMAWCA: Conference of Ministers of Agriculture of West and Central Africa; COMESA: Common Market for East and Southern Africa; ECCAS: Economic Community of Central African States; ECOWAS: Economic Community of West African States; FAAP: Framework for African Agricultural Productivity; FAFS: Framework for African Food Security; FARA: Forum for Agricultural Research in Africa; FIMA: Framework for the Improvement of Rural Infrastructure and Trade-related Capacities for Market Access; M&E: monitoring and evaluation; NEPAD: New Partnership for Africa's Development; RECs: regional economic communities; ReSAKSS: regional strategic and knowledge support systems. RIF: regional implementation framework; SADC: Southern African Development Community; SLWM: sustainable land and water management; UNZA: University of Zambia.

At the country level, the CAADP implementation process aligns national agricultural sector policies, strategies, and investment programs with CAADP principles, pillars, and targets. In particular, the process is focused on achieving a 6 percent national agricultural growth rate and allocating 10 percent of national budgets to the agricultural sector. The process builds on ongoing country efforts and is led by national governments and key stakeholders, with coordination by the regional economic communities (RECs).

4. ANALYTICAL FRAMEWORK AND EMPIRICAL MODEL

Following Alesina, Angeloni, and Etro (2001), we present a framework of a common agenda whereby a group of countries decides together on the provision of certain public goods and policies because of spillovers originating from neighboring countries.

Consider a group of *N* countries with the population size normalized to 1; the utility function of the representative individual of country *i* is given by

$$U_i = c_i + \alpha_i H(g_i), \tag{1}$$

where g_i is the per capita and total level of government spending in country *i*, c_i is private consumption, $H_g(.) > 0$, and $H_{gg}(.) < 0$. The parameter $\alpha_i > 0$ captures how much a representative individual of country *i* values public consumption relative to private consumption.

If all *N* countries decide on a common agenda in the form of a union, the utility function of the representative individual in member country *i* is as follows:

$$U_i = c_i + \alpha_i H(g_i + \rho \sum_{j=1, j \neq i}^{N} g_j), \tag{2}$$

where $\rho \in [0,1]$ represents the spillover effects from other countries' government spending on the "home" country. Furthermore, if each country has a balanced budget, $g_i = t_i \in [0, y]$, and therefore the utility function becomes

$$U_i = y - g_i + \alpha_i H(g_i + \rho \sum_{j=1, j \neq i}^{N} g_j), \tag{3}$$

where y is income and t_i is lump sum taxes raised in country *i*.

If every country acts independently, taking as given the spending of all the other countries, the first-order condition with respect to g_i is given by

$$\alpha_i H_{g_i}(g_i + \rho \sum_{j \neq i} g_j) = 1. \tag{4}$$

In the case of collective action, whereby each country takes into account other countries' expenditures endogenously, the optimality condition for each country is given by

$$\alpha_i H_g(g_i + \rho \sum_{j \neq i} g_j) = 1 - \rho \sum_{j \neq i} \alpha_j H_g(g_j + \rho \sum_{k \neq j} g_k). \tag{5}$$

It follows that unless $\rho = 0$, the Nash equilibrium from the first-order condition (4) is inefficient because countries' behaviors do not account for the effects of their decisions on other countries. The solution $g^*(\alpha_i)$ from system (5) is efficient because it incorporates spillover effects. As pointed out by Alesina, Angeloni, and Etro (2001), this first best policy requires that the union dictate a different policy for each country and that the policy preferences of every country be known and verifiable. Although these conditions seem highly unrealistic in practice, the CAADP agenda has provisions that meet these conditions: (1) CAADP is built around common goals in terms of agricultural growth, poverty reduction, and agricultural investment, but the actual design of agricultural strategies is left to individual countries; and (2) the CAADP peer-review mechanisms allows for regular verification of countries' policy preferences.

If $\rho = 0$, the welfare outcomes with common agenda and without common agenda are qualitatively equivalent. In this case independent policy setting is more efficient than collective action given the cost of union participation.

The purpose of this paper is therefore to estimate ρ. We use an unconstrained spatial Durbin model for panel data as described below.

Given geographical proximity between countries, each country's agricultural production can be expressed as a Cobb-Douglas production function:

$$y_i = A_i \exp(u_i) \prod_{r=1}^{p} s_r^{\beta_r}, \tag{6}$$

where A_i represents country *i*'s total factor productivity; $u_i = \rho w_{ij} u_i + \varepsilon_i$ is an autoregressive (AR) spatial error term; ε is an error term with mean zero and constant variance; ρ represents substantive agricultural spatial spillover; β represents elasticity of production with respect to input s; and w_{ij} are elements of the spatial weight matrix *W* that describes geographical proximity among countries. For convenience, matrix *W* is row-standardized.

Since we do not observe policy interactions between countries, we specify the production function as a spatial error model. As a result, replacing u with $(I - \rho W)^{-1}\varepsilon$, equation (6) yields a spatial Durbin model (SDM) in log linear form:

$$y = \rho W y + S\beta + WS\theta + \iota_n \alpha + \epsilon, \tag{7}$$

where y is an *n* x *1* vector of observations on agricultural production for each country; S is an *n* x *k* matrix of observations on *p (r = 1, ..., p)* agricultural inputs for each of the *n* countries; $\iota_n$is an *n* x *1* vector of ones.

As pointed out by LeSage and Fischer (2008), the SDM nests most models used in applied spatial econometrics literature: (a) if $\theta = 0$, equation (7) becomes a spatial autoregressive (SAR) model that includes a spatial lag of agricultural production from related countries but excludes these countries' agricultural inputs; (b) if $\theta = -\rho\beta$, it becomes a spatial error model (SEM); (c) if $\theta = 0$ and $\rho = 0$, it is a nonspatial least-squares agricultural production model that assumes countries' productions are independent. LeSage and Fischer (2008) show that equation (7) can be rewritten as

$$y = \sum_{r=1}^{p} K_r(W) x_r + V(W)\iota_n \alpha + V(W)\varepsilon, \tag{8}$$

where $K_r(W) = V(W)(I_n \beta_r + W\theta_r)$ and $V(W) = (I_n - \rho W)^{-1}$. It follows that the marginal effect of y_i with respect to s_{jr} can be derived as follows:

$$\frac{\partial y_i}{\partial s_{jr}} = K_r(W)_{ij} = (I_n - \rho W)^{-1} \times (I_n \beta_r + W\theta_r). \tag{9}$$

For the own derivative of the i^{th} country, Pace and LeSage (2006) show that

$$\frac{\partial y_i}{\partial s_{ir}} = K_r(W)_{ii}, \tag{10}$$

where $K_r(W)_{ii}$ captures the impact on country *i* from a change in s_r of country *i* itself.

Empirical inference of model (7) is conducted using tests presented in the appendix . The presence of spillover has the potential to affect growth convergence. NEPAD's CAADP targets are for each country to achieve at least six percent agricultural growth every year; this indicates that at some point African countries will achieve a convergence stage where the slow-growing agricultural sectors will catch up with the fast-growing ones.

To test the potential for agricultural growth convergence, we adapt the β-convergence approach (Barro and Sala-i-Martin 1995), which suggests that on average, poor countries grow faster than rich ones

(developing regions would be catching up with more advanced regions). In other words, β-convergence implies a negative correlation between growth rates of per capita agricultural production and its initial levels. Table 1 presents spatial and nonspatial specifications used to test for convergence.

Table 1. Spatial and nonspatial model for convergence

	Unconditional	Conditional
Nonspatial	$\frac{1}{T} ln\left(\frac{p_{it}}{p_{i0}}\right) = \alpha + \beta ln(p_{i0}) + \mu_i + \varepsilon_i$, where p_{it} is per capita agricultural production, μ_i denotes country-specific effect, T is the length of time under consideration, and $\varepsilon_i \sim iid(0, \delta_\varepsilon^2)$.	$\frac{1}{T} ln\left(\frac{p_{it}}{p_{i0}}\right) = \alpha + \beta ln(p_{i0}) + \gamma X_{it} + \mu_i + \varepsilon_i$, where X_{it} represents the set of agricultural inputs for country i in period t.
Spatial	$\frac{1}{T} ln\left(\frac{p_{it}}{p_{i0}}\right) = \alpha + \beta ln(p_{i0}) + \mu_i + \varepsilon_i$ $\varepsilon = \rho W\varepsilon + u$, $u \sim iid(0, \delta_u^2)$	$\frac{1}{T} ln\left(\frac{p_{it}}{p_{i0}}\right) = \alpha + \beta ln(p_{i0}) + \gamma X_{it} + \varepsilon_i$

Source: Adapted from Barro and Sala-i-Martin 1995.
Note: The convergence speed is given by $\tau = -ln(1 - \hat{\beta}T)/T$.

Descriptive Analysis

Panel data were collected on 48 countries in Sub-Saharan Africa from 1961 to 2006. Traditional inputs are from the FAOSTAT database (FAO 2009) and Fuglie 2008. They include agricultural output, fertilizers, livestock, tractors, labor, and land quality. The summary statistics are presented in Table 2 with means, standard errors, minimum, and maximum values of the variables (output, traditional inputs, land quality, and inefficiency are changing variables).

Agricultural land is measured as the sum of pastureland and permanent crops in thousand hectares (not adjusted for quality). Fertilizer use is measured as the quantity of fertilizer plant nutrient consumed (tons of N, P_20_5, and K_20). Agricultural labor is measured as the number of persons (male and female) economically active in thousands. Farm machinery is the number of agricultural tractors in use. The livestock variable is the number of cattle equivalents aggregated using Hayami-Ruttan weights (Fuglies).

Table 2. Descriptive statistics

Variable	Obs.	Mean	SE	Minimum	Maximum
Production	2162	1254.9	2072.0	5.9	12251.7
Land	2162	20.2	25.6	0.0	113.1
Fertilizer	2162	34.0	107.4	0.0	720.3
Labor	2162	3.0	3.9	0.0	18.7
Machines	2162	5.5	19.7	0.0	134.9
Livestock	2162	5282.3	8597.1	7.3	43568.5

Source: Authors' computation.
Note: Agricultural gross production (constant 1999–2001, US$1,000, smoothed using the Hodrick-Prescott filter with λ = 6.25) is used as a measure of agricultural production (Fuglie 2008).

Table 3 presents the number of countries by growth range and subperiod over 1961–2006. Across subperiods, the majority of countries have achieved 4 percent growth or less. However, the results suggest different trends across both locations and time. The highest number of countries (10) with negative growth rates is observed during the 1971–1980 subperiod. This corresponds to the period when exchange rates in some countries became overvalued in order to make imports cheaper and raise the price of exports. However, the overvaluation of the exchange rate discouraged exports of primary commodities,

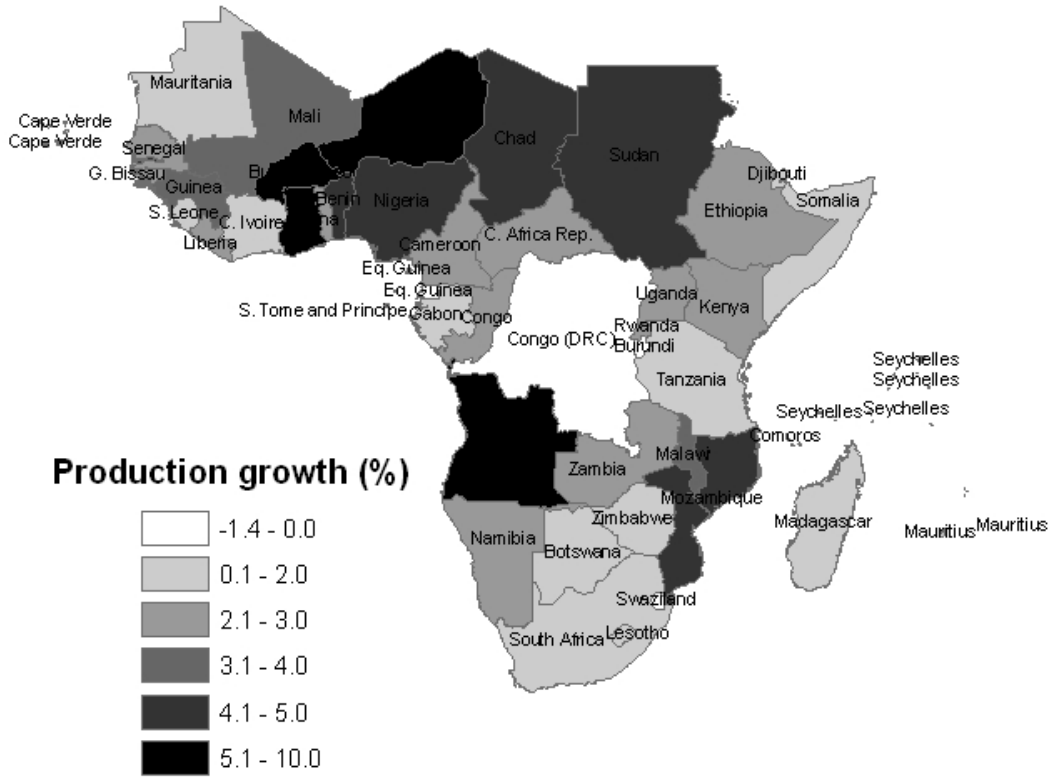
which included agricultural crops. High population growth rates, growing urban populations, and overvalued exchange rates promoted an increase in food imports while the price of nontradables increased relative to food imports (Delgado 1995). Over the 1991–2006 subperiod, 29 out of 47 countries achieved growth rates ranging from 1 to 4 percent (see Table A.1 for complete list of agricultural growth rates by country and subperiod). As shown in Figure 2, the west African region registered the highest growth rate during the period 1999–2005, at 5 percent compared to the African average of 3.3 percent.

Table 3. Distribution of countries by growth range and subperiod

	1961–1970	1971–1980	1981–1990	1991–2006
<0.0	4	10	5	4
0.1-2.0	6	17	15	16
2.1-3.0	15	7	8	13
3.1-4.0	14	7	10	3
4.1-5.0	5	4	3	7
5.1-6.0	1	1	4	3
>6.0	2	1	2	1
Total	47	47	47	47

Source: Authors' computation.

Figure 2. Agricultural production growth, 1991–2006



Source: Authors' compilation.

Estimation Results

Regression results are presented in Table 4. Overall, except for machinery, production elasticities in relation to countries' own inputs are positive and significant: 0.689 for land, 0.034 for fertilizer, 0.379 for labor, and 0.430 for livestock. The results suggest the presence of significant externalities or neighboring-country production effects on countries' agricultural production, with the elasticity of agricultural production in relation to neighboring countries being 0.039 over the 1961–2006 period. In other words, on average, a 1 percent increase (decrease) in agricultural production in neighboring countries increased (decreased) agricultural production in the home country by 0.039 percent. After a sharp decline during 1971–1980, the neighboring country effect increased to 0.179 during 1991–2006, the period in which NEPAD's CAADP agenda was adopted by African leaders.

With respect to inputs, we found negative and significant effect of neighbors' elasticity of labor during the period 1981–1990 (-0.019). Although negligible, this implies that an increase (decrease) in the use of agricultural labor in neighboring countries has the potential to lead to a decrease (increase) in agriculture production in the home country. This finding makes sense if one assumes a fixed labor supply and spatial mobility of agricultural labor among Sub-Saharan African countries.

Negative significant externalities are found for machine use in 1971–1980. This finding suggests that there is a risk that, if left uncoordinated, intensive use of inputs by one country can lead to a decrease in production in neighboring countries. On average, the pace of agricultural mechanization in Sub-Saharan Africa has been slow due to the high costs of implementation and low effectiveness of modern agricultural equipment (Pingali, Bigot, and Binswanger 1987). Government-run tractor programs in the 1960s and early 1970s were largely ineffective as a result of management failures, shortfalls of government financial support, and poor supporting infrastructures (Mrema, Baker, and Kahan 2008).

In the literature, two terms are used to characterize policy spillover effects: (1) beggar-thy-neighbor policies, those that attempt to remedy the economic problems in one country through mechanisms that tend to worsen the problems of other countries (Robinson 1937); (2) prosper-thy-neighbor policies, those that generate positive spillovers of a country's agricultural production onto a neighboring country's production (Corsetti and Pesenti 2001).

Using agricultural growth rates as an outcome of agricultural policies, the results reported in Figure 3 suggest that on average, no country experienced negative spillovers due to its neighbors. In contrast, on average, each country attained 2.5 percent growth as a result of spillover from neighbors. Even countries with negative actual agricultural growth such as Equatorial Guinea (-0.5 percent), Swaziland (-0.6 percent), DRC (-1.4 percent), and Burundi (-0.2 percent), benefited from positive spillover growth rates of 1.8 percent, 2.5 percent, 2.5 percent, and 3.1 percent, respectively. Ethiopia (4.4 percent), Uganda (4.4 percent), Nigeria (4.4 percent), Comoros (3.7 percent), and Zambia (3.5 percent) were the top beneficiaries from the production effects of their neighbors.

The results confirm the potential for convergence of per capita agricultural growth among Sub-Saharan countries. Both spatial and nonspatial specifications support the hypothesis that countries lagging in terms of per capita agricultural growth are catching up with the leading countries. As shown in Figure 4, the potential for convergence is much higher when spatial spillover is accounted for. In addition, the use of agricultural inputs in the production function specification substantially improves convergence.

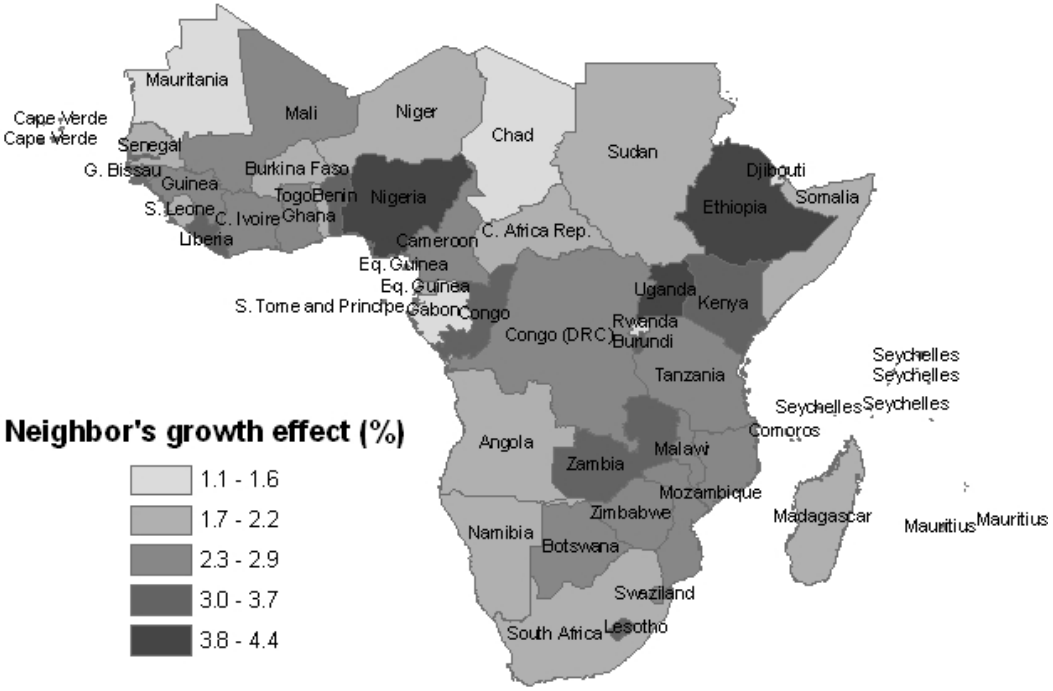
Figure 5 presents the speed of convergence by model specifications. It appears that incorporating spatial and conditional specifications leads to higher speed of convergence than with nonspatial and unconditional specifications respectively. This confirms the important role of spatial spillover in achieving a common agenda such as the six percent growth target under the CAADP agenda.

Table 4. Regression results

	All		1961–1970		1971–1980		1981–1990		1991–2006	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
Neighbors' outputs elasticities										
Spatial lag	0.039[a]	0.021	0.275[a]	0.048	-0.021	0.064	0.062[b]	0.047	0.179[a]	0.037
Own inputs elasticities										
Land	0.689[a]	0.024	0.664[a]	0.050	0.874[a]	0.077	0.495[a]	0.037	0.641[a]	0.063
Fertilizer	0.034[a]	0.003	0.025[a]	0.006	0.023[a]	0.007	0.010	0.007	0.011[a]	0.004
Labor	0.379[a]	0.020	0.561[a]	0.078	0.378[a]	0.068	0.501[a]	0.059	0.478[a]	0.054
Machines	0.004	0.006	0.008	0.008	-0.016	0.019	0.110[a]	0.021	-0.046[b]	0.019
Livestock	0.430[a]	0.014	0.112[a]	0.034	0.311[a]	0.045	0.400[a]	0.033	0.404[a]	0.033
Neighbors' inputs elasticities										
Land	-0.003	0.008	0.008	0.007	0.000	0.012	0.005	0.009	-0.001	0.009
Fertilizer	-0.001	0.004	0.000	0.004	0.004	0.007	-0.003	0.005	0.001	0.005
Labor	0.000	0.008	0.005	0.008	-0.001	0.013	-0.019[b]	0.009	0.010[b]	0.008
Machines	-0.007	0.005	-0.003	0.004	-0.013[c]	0.007	-0.005	0.005	0.004	0.005
Livestock	0.012	0.009	-0.010	0.007	0.014	0.012	0.008	0.010	-0.014	0.010
#Obs.	2162		470		470		470		752	
LM robust test	15.5	p-value=0.00	36.7	p-value=0.00	0.8	p-value=0.36	5.8	p-value=0.02	44.8	p-value=0.00

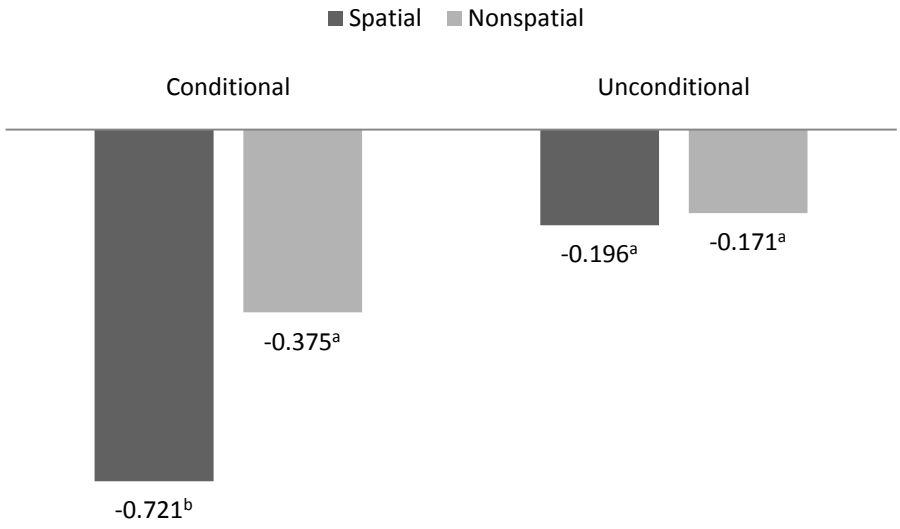
Source: Authors' computation.
Notes: [a] significant at 1%; [b] significant at 5%; [c] significant at 10%.

Figure 3. Agricultural growth effects from neighboring countries (%)



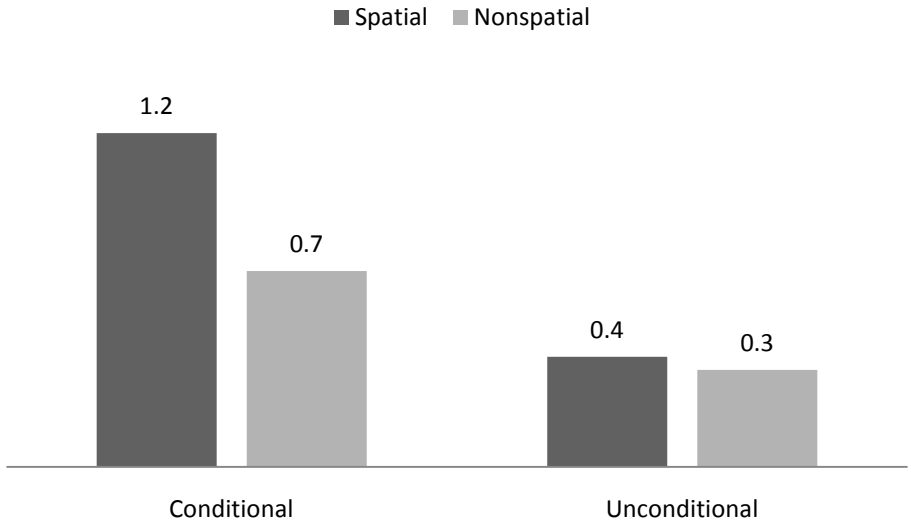
Source: Authors' computation.

Figure 4. β-convergence



Source: Authors' computation.
Notes: [a] significant at 1%; [b] significant at 5%.

Figure 5. Speed of convergence



Source: Authors' computation.

5. CONCLUSIONS AND IMPLICATIONS

Both theory and empirical evidence clearly suggest that geographical proximity can generate spillovers that ultimately affect agricultural growth dynamics across countries. The adoption of a common union is often rationalized on grounds of moving the equilibrium toward the first best solution whenever independent policies generate spillovers. This arises because a common agenda can significantly reduce the scope of free-riding behavior among member countries. In addition, cross-border externalities arising out of higher levels of market integration require countries to agree upon policy coordination relative to the option of breaking the ranks.

Using a spatial Durbin model for panel data, the present study examined the extent and magnitude of agricultural production spillover that might validate the adoption of the CAADP agenda among Sub-Saharan African countries. Overall, our results suggest the presence of positive agricultural production spillovers. No evidence of beggar-thy-neighbor or negative spillover policies was found. On average, each country achieved 2.5 percent growth as a result of spillover. Finally, our results suggest that convergence dynamics are much stronger when spillover is accounted for, which provides a rationale for a common agenda such as CAADP.

APPENDIX: TESTS AND SUPPLEMENTARY TABLE

Tests of spatial correlation:
The Moran's *I* for regression residuals is given

$$I = \frac{n}{S_0}\frac{e'We}{e'e}, \tag{11}$$

where e is the $(n \times 1)$ vector of OLS residuals.

There are several tests with well-designed alternative hypotheses:

1. Lagrange multiplier test for spatial error:

$$LM_\lambda = \frac{1}{T}\left(\frac{e'We}{s^2}\right)^2, \tag{12}$$

where $s^2 = e'e/n$ is the maximum likelihood (ML) variance and $T = tr(W'W + W^2)$, with tr being the matrix trace operator.

2. Lagrange multiplier test for spatial lag:

$$LM_\rho = \frac{1}{nJ_{\rho.\beta}}\left(\frac{e'Wy}{s^2}\right)^2, \tag{13}$$

where $J_{\rho.\beta} = [(WXb)'M(WXb) + Ts^2]/ns^2$ is part of the ML estimated information matrix, b is the vector of OLS estimated parameters, and $M = [I - X(X'X)^{-1}X']$.

We also use robust tests developed by Anselin and colleagues (1996):

3. Robust Lagrange multiplier test for spatial error:

$$LM_\lambda^* = \frac{1}{T - T^2(nJ_{\rho.\beta})^{-1}}\left(\frac{e'We}{s^2} - T(nJ_{\rho.\beta})^{-1}\frac{e'Wy}{s^2}\right)^2, \tag{14}$$

where $s^2 = e'e/n$ is the maximum likelihood variance and $T = tr(W'W + W^2)$, with tr being the matrix trace operator.

4. Robust Lagrange multiplier test for spatial lag:

$$LM_\rho^* = \frac{1}{nJ_{\rho.\beta} - T}\left(\frac{e'Wy}{s^2} - \frac{e'We}{s^2}\right)^2. \tag{15}$$

These tests asymptotically follow an χ^2 distribution with one degree of freedom.

Table A.1. Agricultural growth rates by country and subperiod

Country	1961–1970	1971–1980	1981–1990	1991–2006
Angola	3.4	-3.0	0.3	5.4
Benin	2.1	2.2	5.9	4.0
Botswana	3.8	-0.2	3.4	0.0
Burkina Faso	3.8	1.1	6.2	5.7
Burundi	2.1	0.8	3.0	-0.2
Cameroon	3.1	2.6	2.0	2.4
Cape Verde	5.4	4.7	3.6	1.9
C. Africa Rep.	4.6	1.9	1.8	2.5
Chad	-1.1	3.6	6.0	2.0
Comoros	1.2	0.8	2.5	4.3
Congo	2.3	1.6	2.2	1.2
Congo (DRC)	1.9	1.1	1.6	2.1
C. d'Ivoire	2.0	1.8	3.0	-1.4
Djibouti	4.8	10.2	7.4	1.3
Eq. Guinea	2.9	-6.4	4.8	-0.4
Ethiopia	2.3	1.5	0.8	2.8
Gabon	-2.3	2.3	4.5	2.6
Gambia	1.8	3.5	1.9	1.5
Ghana	2.5	-2.5	3.9	4.8
Guinea	3.0	-0.8	2.3	7.1
G. Bissau	1.9	1.5	1.1	3.8
Kenya	3.1	3.6	4.6	2.3
Lesotho	1.6	1.5	1.5	0.8
Liberia	4.3	2.2	-1.3	2.7
Madagascar	2.9	1.5	1.6	1.4
Malawi	3.3	4.4	1.8	3.8
Mali	3.3	2.0	3.7	3.2
Mauritania	1.7	0.7	1.6	1.4
Mauritius	2.3	1.0	3.0	0.6
Mozambique	3.3	-0.5	0.2	4.3
Namibia	3.4	1.7	-0.8	2.4
Niger	2.6	3.5	1.6	5.4
Nigeria	4.6	-1.5	5.7	4.2
Rwanda	6.5	3.4	2.2	2.7
S. Tome and Principe	3.1	1.2	2.0	1.5
Senegal	-0.4	-2.5	-1.5	4.7
Seychelles	-1.4	5.7	5.6	2.4
S. Leone	2.4	-0.2	-0.5	1.8
Somalia	3.9	2.5	1.2	0.5
South Africa	2.6	3.5	1.2	1.5
Sudan	3.6	2.7	-0.1	4.5
Swaziland	4.6	4.2	2.2	-0.6
Tanzania	3.9	3.0	2.7	1.7
Togo	2.7	1.3	3.3	2.9
Uganda	7.5	-2.5	3.8	2.1
Zambia	2.3	3.6	3.0	2.5
Zimbabwe	3.6	4.3	3.0	0.4

Source: Authors' computation.

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